THE SOURCE OF OUR COLD WAVES.

By Director R. F. STUPART. Dated Toronto, March 3, 1909.

I send you the January tracks (Chart IX) and the tracks for the other months will follow almost immediately. I also send you a map (Chart X) with the isobars drawn based on the reports from the far north stations.

A comparison of the mean barometric pressures in the far north for January, 1907, and January, 1908, is most interesting. In the former year the mean pressure at Dawson was 30.70 inches (sea level) and the distribution of mean pressure over Canada and the Northwestern States led to a persistent northeasterly gradient over the whole northern region, and hence extremely cold weather was experienced between latitudes 60° N. and 45° N. It is worthy of note, however, that the Dawson temperature in latitude 64° N. was only just normal. In 1908 the mean pressure at Dawson was 29.90 inches, and there was a totally different distribution of pressure over the Western States and northern Canada; the prevailing gradient was for southwesterly winds. The whole of our Western Territories were decidedly warmer than the average. It appears fairly evident that the wide negative departures in Alberta and Saskatchewan during January, 1907, and again in this past January, were perhaps altogether due to the persistent transference of air from the higher latitudes, and the equally wide positive departures in 1908 were due to the equally persistent southwesterly gradient.

I believe that a study of the far north with reliable barometer readings will be most valuable. Apparently the high pressures in Yukon are not wholly the outcome of extreme cold caused by radiation. The coldest January of which we have record was that of 1906, when the mean pressure was 30.26 inches and the mean temperature —34°, while in southern Saskatchewan and Alberta that month was phenomenally mild, with persistent southwesterly winds.

The high pressures in Siberia are certainly not altogether the outcome of the continental cold, as the lowest temperature is far north of the highest mean pressure, which is an extension and an intensification of the extratropical belt of high pressure. It thus appears to me that the persistent high pressures found in some seasons in the far north owe their origin to upper currents from the equator coming to earth farther north than usual. Indeed the formation of the ordinary high is probably due to this, but we may very probably in the future connect the situation in the equatorial regions and trade-wind belts with that in the high latitudes.

THE CLIMATE OF THE GLACIAL EPOCH.[1]

By HENRYK ARCTOWSKY, Brussels.

[Translated by C. Abbe, jr.]

It is well known that the snow line at any locality does not depend solely on the local mean temperature, but is also determined by other climatic factors, such as the amount of insolation and the character of the seasons. The local topography and the amount of annual precipitation are also equally important.

In order to determine the influence of one of the factors, e. g., the temperature, it is necessary that all the other factors remain constant. Thus, let us suppose for the sake of simplicity that we have an isolated mountainous island in the ocean, and that this island may shift its position along its meridian. If the island is moved into a region where all the climatological conditions except temperature remain the same, then the change in altitude of the snow line will express the influence of the variable factor.

To determine the fall in the mean temperature of a given region during the glacial epoch, at least in a wholly marine climate, it would be necessary to find a second identical region exposed to the same winds, having the same cloudiness and precipitation, and whose actual present glaciation has the same extent as did the previous glaciation of the first region.

Now it seems to me that we should be able to find some examples of this kind somewhere in the Southern Hemisphere; but the difficulties are undoubtedly numerous, and we may not hope to find more than a mere approximation to the climatic conditions of the glacial epoch.

Thus, as is well known, the atmospheric precipitations of mountainous regions are not the same at all heights, whence we may conclude that they would very probably show similar variations on an isolated island. As we advance toward the poles, or the colder regions, the zone of maximum precipitation having entered the zone of snowfall experiences a sudden change, and at once the limit of snowfall will descend more slowly with the progressively diminishing rate at which the temperature falls. But here enters another difficulty, viz, the altitude of the clouds seems to diminish with increasing latitude.

Furthermore, the courses of the ocean currents may have changed since the glacial epoch, or to speak more accurately—since the surficial marine currents depend almost entirely on the prevailing winds—the region of equatorial calms may have shifted, the trade winds, the permanent highs, and the tracks of cyclonic storms may have occupied quite different positions from what they do to-day. Croll's hypothesis[2] requires this, and the fact that there were extensive glacial ice caps renders it yet more probable.

Again, there is a no less important difficulty, the present positions of the glaciated lands with reference to sea-level are in many cases no longer the same as during the time of maximum glaciation, and Rudzki[3] has demonstrated the probability of the submersion of the lands under the weight of accumulated ice.

In any case, then, a more profound study of the region will have to consider the question: By how many degrees centigrade must the mean temperature be lowered (every thing remaining the same in other respects) in order to lower the line of permanent snow by n meters?

So far as concerns the Alps Penck admits that the permanent snow line there stood lower by about 1,000 meters, and Brückner believes that the mean temperature of the glacial epoch at the time of maximum glaciation was only 3° or 4° C. lower than it is to-day.[4] Oswald Heer[5] was also led, by his paleontological studies, to the conclusion that the mean temperature was then lower by 3° or 4° C.

Nevertheless it seems to me that these figures do not suffice unless we admit, a priori, a climate much more humid than the present, and that a much greater difference in temperature is necessary to lower the snow line by 1,000 meters if the precipitation was the same then as now.[6]

To demonstrate this I compare the region of Cape Horn with the island of South Georgia, the latitude of both is the

[1] This article appeared in the Bulletin de la Société Belge d'Astronomie, Juin, 1908, No. 6, p. 220-231, as an extract from the author's memoir on the present and former glaciation of the channels of Tierra del Fuego and the Antarctic Continent, as discovered by the *Belgica*, about to appear in the Rapports scientifiques de l'expedition antarctique belge.

[2] James Croll: Climate and time. London. 1875.

G. Pilar: Ein Beitrag zur Frage die Ursachen der Eiszeit. Agram. 1876. Pilar, starting with Croll's idea, demonstrated that the tropical calm belt was necessarily displaced; but did not take account of the influence of this shifting upon the general atmospheric circulation of the whole globe.

[3] Rudzki. Bul. internat. de l' Acad. des Sci. de Cracovie, 1899, p. 169.

[4] Klimaschwankungen seit 1700. Vienna. 1890. p. 308.

[5] See A. Helm: Handbuch der Gletscherkunde. Stuttgart. p. 560.

[6] T. G. Bonney thinks that it would require a lowering of 18° F. (10° C.) to produce a glacial epoch if the temperature distribution of the Northern Hemisphere remained the same as to-day. See Geog. Jahrb., 1893, p. 24.

same, 54° south; the difference in longitude is 30°. Both have a marine climate with prevailing west winds.

Station.	Mean temperature.	Days with rain or snow, 1882–83.	Precipitation.	Snow line.
	°C.		Mm.	Meters.
Cape Horn[7]	5.5	278	1,400	900
South Georgia[8]	1.4	301	900	600
Differences	4.1		500	300

The difference in precipitation is due, without doubt, to differences in the exposure of the observing stations, and probably as a matter of fact the precipitation is the same at corresponding altitudes at both places. From the geomorphologic point of view the islands west and south of Tierra del Fuego are comparable in all respects with the island of South Georgia. The altitude of the perpetual snow line in the Magellanic region[9] is 900 meters, while on the northeast coast of South Georgia[10] it stands at 600 meters.

Together with a difference of 4° C. in the mean temperature there is here a difference of about 300 meters in the two levels of perpetual snow.

In fact it seems to me useless to insist any longer on the example selected, since the elevation of the line of perpetual snow is not sufficiently well known, while our knowledge of the topography of South Georgia and of the islands of Tierra del Fuego is even less satisfactory.

Moreover, this example will inevitably be criticised, and without doubt those geologists holding to the theory of a moister climate will point out that the level of the line of perpetual snow corresponds with a great variety of isotherms, ranging between the isotherms of +3° in the Andes near Quito and that of —10° or —11° C. in Spitzbergen and Nova Zembla,[11] or even more. In fact, one may readily accuse me of partiality and claim that the above example has been chosen with the direct purpose of showing that the climate of the glacial epoch must have been much more rigorous than we have presumed. It will certainly be maintained that only a general discussion of all the known facts can have decisive value, and that in any case we should take the mean of all the numbers obtained. I do not contest this, but nevertheless in the actual state of our knowledge it is preferable to limit ourselves to the selection of illustrations from regions where the climate is now and has been essentially marine, choosing by preference oceanic islands. Therefore the example given seems to me well chosen.

Another good example deserving of thoro study and discussion is the comparison of the region about the Straits of Tierra del Fuego with the antarctic continent lying south of Cape Horn. Both regions are mountainous and exposed to oceanic winds, which bring abundant precipitation; but the altitude of the snow-line in the polar lands is lower by about 800 meters, and the actual appearance of this land is very probably that which the region about the Straits of Tierra del Fuego must have presented at the time of maximum extension of Pleistocene glaciation. What, now, are the mean temperatures of these two regions? We have but few available data for the Straits of Tierra del Fuego and still less for the antarctic lands. The known means are as follows:

Magellanic region.	°C.	*Antarctic region.*	°C.
Punta Arenas[12]	6 7	Snow Hill[16]	—11.8
Ushuwaia[13]	6.5	Scotia Bay[17]	— 5.4
Cape Horn[14]	5.5	Wandel Island[18]	— 5.4
Staten Island[15]	6.3		

We thus have a difference of level of the snow line of 800 to 900 meters, corresponding to a difference in the mean temperature of at least 10° to 12° C.

If a more thoro study of the topography and the meteorological conditions of the two regions permits us to maintain this analogy, the data already secured will not fail to clear up a part of the problem of the climate of the glacial epoch. We may at least determine how many degrees fall in temperature must occur in the Magellanic region in order that the ice again descend to the level that it then occupied. I would emphatically declare that when one speaks of the lowering of temperature that accompanied the glacial epoch in the Magellanic region and sets the same at 4° C. one speaks as tho this number applied indifferently to all the regions of the globe.

Now it is inconceivable that inland ice caps such as existed in northern Europe and North America, should not have profoundly modified the meteorological regimen of neighboring regions and even the general atmospheric circulation of the whole Northern Hemisphere. The distribution of climates, even in the regions beyond the ice-invaded country, must have been incontestably at variance with the present, so that for this reason alone it seems to be inadmissable to assume that the fall in temperature went on in a similar manner everywhere, and that it may be exprest by a simple difference—and that the same difference—from the mean annual temperature.

A PLEA FOR TERRESTRIAL AND COSMICAL PHYSICS.[1]

By Dr. L. A. BAUER, Carnegie Institution of Washington. Dated December, 1908.

Once upon a time, at a certain small dinner party, the Duke of Wellington on being urged to express his opinion frankly of the French marshals he had so successfully worsted in battle, pointed out their good qualities in a most free and magnanimous manner, showing wherein each particularly excelled. Whereupon one of the party said, "Well, sir, how was it that with such various great qualifications you licked them all, one after another?" The Duke, taken a-back, paused, then said, "Well, I don't know exactly how it was, but I think if any unexpected circumstances occurred in the midst of a battle which deranged its whole plan, I could perhaps organize another plan more quickly than most of them."

This quality of mind, to instantly change an established train of thought or to be receptive to a new set of circumstances and facts, and thus to be capable of immediately setting up a fresh plan of action, was tersely and most suggestively exprest by Maxwell when writing Herbert Spencer about a subject of controversy in the latter's "First Principles:"

> It is seldom that any man who tries to form a system can prevent the system from forming around him and closing him in before he is forty. Hence the wisdom of putting in some ingredient to prevent crystallization and keep the system in a colloidal condition.

At the Ithaca meeting of the Association two years ago last summer, I prefaced a paper on the San Francisco earthquake by a few remarks calling attention to the disparity of papers pertaining to the physics of the earth and of the universe presented to-day before Sections A and B. I stated it was

[7] Lephay: Mission scientifique du Cape Horn. Vol. II, p. 138.
[8] Die Internationale Polarforschung, 1882–3. Die Beobachtungs Ergebnisse der Deutschen Station. Vol. II, p. 138.
[9] According to the officers of the *Beagle*, 1,000 meters; according to Pissis, 800 meters; according to Thomas Bridges, 900 to 1,000 meters.
[10] Hann: Klimatologie. 1897. Vol. III p. 467.
[11] Hann: op. cit., I, p. 313. See Hann-Ward, 1903, p. 321–322.
[12] Arctowsky. Ciel et Terre, 16 juin 1900.
[13] Lephay: Mission scientifique de Cap Horn. Tome II, p. 138.
[14] Lephay: ibid., p. 271.
[15] Arctowsky. Ciel et Terre, 1 decembre 1900.
[16] Bodman. Petermann's Geogr. Mittheilungen, 1904, Hft. 5.
[17] Mossman, Scottish Geog. Mag., August 1905.
[18] J. J. Rey in Charcot: Les Français au Pole Sud. p. 367.
[1] Presented at the Baltimore meeting (1908–9) of the American Association for the Advancement of Science, before the General Interest meeting of Section B (Physics).